Appendix 7F
Sites Reservoir Discharge Temperature Modeling

APPENDIX 7F
Sites Reservoir Discharge Temperature Modeling

7F.1 Overview and Description

7F.1.1 Introduction

This appendix describes the modeling analysis performed for estimating the temperature potential of discharges from the proposed Sites Reservoir. This analysis was prepared to support the detailed evaluation of North-of-the-Delta Offstream Storage (NODOS) alternatives for the NODOS Draft Environmental Impact Report/ Environmental Impact Statement (NODOS DEIR/EIS).

The potential impact on Sacramento River temperature conditions, downstream of the proposed Delevan Pipeline, due to the proposed Sites Reservoir releases, was evaluated. The analysis was prepared only for Alternative C. The potential impacts were determined by comparing the results of the analysis of Alternative C with the temperature modeling results for the No Project/No Action Alternative presented in Appendix 7E.

7F.1.2 Assumptions

The assumptions describing the modeling of alternatives are presented in Appendix 6A. The analytical framework for the detailed evaluation of the alternatives is presented in Appendix 6B.

Alternative C was used as a surrogate to identify the potential impact on Sacramento River temperature conditions, downstream of the proposed Delevan Pipeline, due to the proposed Sites Reservoir releases:

- Alternative C has a 1.8-MAF storage capacity with existing Tehama-Colusa Canal (2,100 cubic feet per second [cfs]) and Glenn-Colusa Irrigation District Canal (1,800 cfs) and a new Delevan Pipeline with a fish screen intake and pumping plant with a diversion capacity of 2,000 cfs and a release capacity of 1,500 cfs.

The scope of this analysis was limited to the modeling of temperature conditions inside the proposed Sites Reservoir and the temperature conditions of the releases from the proposed Delevan Pipeline into the Sacramento River. Alternative C was analyzed assuming that it would result in the worst-case impact to the Sacramento River temperature conditions downstream of the proposed Delevan Pipeline.

The daily operations of the proposed Sites Reservoir and Delevan Pipeline are derived from the simulation of the USRDOM model. The inflow temperatures into the proposed Sites Reservoir and the temperature targets used for operating the proposed selected withdrawal control structure at the proposed Sites Reservoir outlet structure are based on Sacramento River downstream temperature conditions derived from the simulation of the USRWQM model. The upper Sacramento River daily operations modeling using the USRDOM model is presented in Appendix 6C. The upper Sacramento River temperature modeling using the USRWQM model is presented in Appendix 7E. This analysis tiered off of the modeling described in these other documents.

7F.1.3 Analysis

A simple single reservoir model was developed to investigate potential temperature and water quality issues with operations of the proposed Sites Reservoir. The model was derived from the Colusa Basin Water Quality Model (CBWQM) previously developed for Reclamation by RMA. The model has also been referred to as the RMA Sites Water Quality Model (RMA, 2005). The CBWQM is based on the HEC-5 and HEC5Q model framework developed by the Army Corps of Engineers (ACOE) Hydrologic Engineering Center (HEC).

HEC-5 inputs for the proposed Sites Reservoir, such as the reservoir levels, storage-capacity-elevation curves, and the initial storage conditions were derived from the USRDOM model simulations for Alternative C (Appendix 6C). Other time-series inputs, such as evaporation rates, inflows, and outflows, were also derived from the USRDOM model. The inflows to the proposed Sites Reservoir were assumed to be the daily flow from Funks Forebay to the proposed Sites Reservoir simulated in the USRDOM model. The outflow from the Sites Reservoir was specified using daily flow from the proposed Sites Reservoir to the Funks Forebay, as simulated in the USRDOM model. Using the information from the USRDOM ensures that the daily operations in the model were consistent with the resulting operations from USRDOM and CALSIM II models (Appendix 6B).

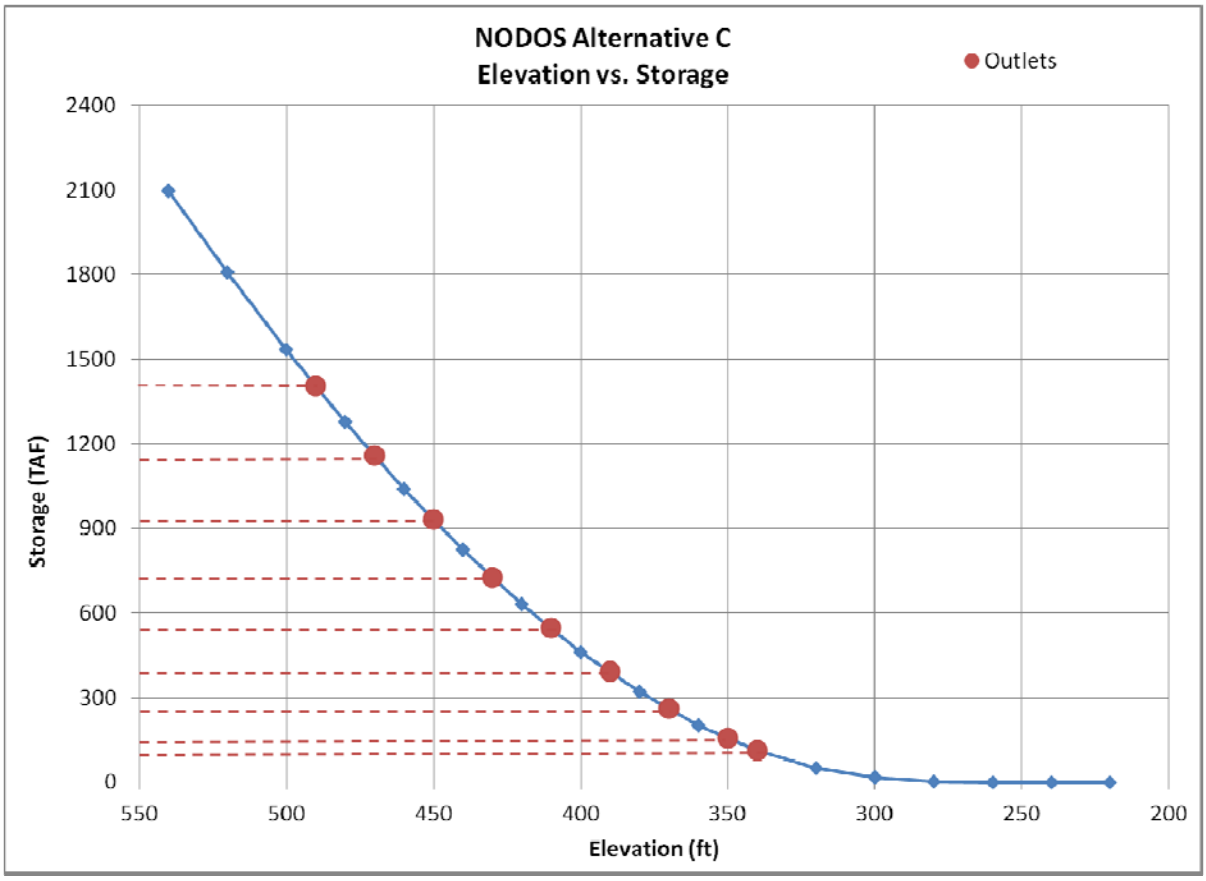
HEC5Q inputs for the proposed Sites Reservoir were derived from the CBWQM (RMA, 2005). The proposed Sites Reservoir was simulated as a vertically segmented reservoir in the HEC5Q model. The inputs, such as the vertical segmentation, kinetic rates, coefficients, and information needed for the thermal calculations in the reservoir, were all based on the CBWQM. The centerline elevations of the outlets in the wet well of the proposed outlet structure were based on the latest available engineering information of Sites Reservoir (Reclamation, 2011). Nine outlets were assumed at elevations 340 feet, 350 feet, 370 feet, 390 feet, 410 feet, 430 feet, 450 feet, 470 feet, and 490 feet Figure 7F-1 shows the relationship of water surface elevations, and specific outlet elevations, corresponding to storage volumes for the proposed Sites Reservoir.

The Sites Reservoir inflow temperature time-series input was derived from the Sacramento River temperatures at the Tehama-Colusa Canal Intake, Glenn-Colusa Irrigation District Intake, and Delevan Pipeline Intake simulated in USRWQM. Sites Reservoir inflow temperature was estimated by weighting the above three temperatures by amount of flow diverted at each of the three intakes for filling Sites Reservoir simulated in USRDOM.

HEC5Q is capable of simulating reservoir temperature by operating withdrawals to meet the specified tailwater temperature objectives. For the Sites Reservoir Temperature Model, these tailwater target temperatures were specified using the monthly average temperatures in the Sacramento River upstream of the Delevan Pipeline simulated in the USRWQM model (this temperature does not vary as a function of the potential temperature of the proposed Delevan Pipeline releases from Sites Reservoir).

The HEC5Q model was used to simulate the temperature conditions in the reservoir and the releases for Alternative C. The proposed Sites Reservoir releases to the Sacramento River were blended with the Sacramento River flow to estimate the water temperatures downstream of the Delevan Pipeline. The blended Sacramento River temperatures were compared to tailwater target temperatures used in the model to determine if there was any warming or cooling impact on the Sacramento River temperatures due to the blending of the water from the Sites Reservoir.

Figure 7F-1
Alternative C Sites Reservoir Storage as a Function of the Reservoir Elevation, with Reservoir Outlets Marked



7F.1.4 Limitations

The parameters for the temperature model for the proposed Sites Reservoir were developed using data from literature and from other reservoirs in the region. Because Sites Reservoir is proposed, and therefore, cannot be observed, the model cannot be validated through in-field temperature observations. The model assumes that the temperature of releases from the reservoir could be changed to meet the target temperature in real-time (at a daily time-step). The target temperatures used for modeling were assumed based on monthly average model simulated temperatures of the river before receiving the water. The output port optimizing logic in the HEC5Q model has limitations. Potential temperature changes within conveyance features that would convey water to and from the proposed Sites Reservoir were not taken into account when computing the inflow temperatures and the resulting blended Sacramento River temperatures.

Alternative C was used as a surrogate for this analysis. NODOS Alternative A and Alternative B differ in the storage or conveyance capacities assumed, however, each alternative is modeled assuming the same objectives for water operations and the same operational policies. The specific assumptions for the other alternatives are as follows:

- Alternative A has a 1.2 MAF storage capacity with existing Tehama-Colusa Canal (2,100 cfs) and Glenn-Colusa Irrigation District Canal (1,800 cfs) and a new Delevan pipeline with a diversion capacity of 2,000 cfs and release capacity of 1,500 cfs.
- Alternative B has a 1.8 MAF storage capacity with existing Tehama-Colusa Canal (2,100 cfs) and Glenn-Colusa Irrigation District Canal (1,800 cfs) and a new release only Delevan pipeline (release capacity of 1,500 cfs). There are no fish screen intake and pumping plant associated with the new Delevan pipeline.

In this analysis, only Alternative C was evaluated, based on the assumption that it is the alternative that would result in the worst-case impact to the Sacramento River temperature conditions downstream of the proposed Delevan Pipeline Intake/ Discharge facilities. Of the three alternatives Alternative C includes the largest configuration of the Sites Reservoir, and the largest intake and discharge facilities. The potential for stratification and coldwater availability is the largest under Alternative C, and similarly, the amount of water discharged to the river is the largest under Alternative C. Other alternatives with either, a smaller Sites reservoir or a smaller discharge facility, potential impacts to the temperature in Sacramento River downstream of the proposed intake will be less than those observed under Alternative C.

7F.1.5 References

Reclamation (2011). Sites Reservoir Golden Gate Dam 1.81 MAF Storage Reservoir Multi-level Inlet/Outlet Tower Structure Sections.

RMA (2005). Upper Sacramento River Models and North of Delta Offstream Storage Model (NODOS), Presentation by Don Smith/RMA to DWR.

7F.2 Results

This section presents the results of the discharge temperature modeling of the proposed Sites Reservoir, as described above.

The analysis was prepared for only Alternative C. Alternative C was used as a surrogate to identify the potential impact on Sacramento River temperature conditions. The resulting changes in Sacramento River flows were in addition to whatever other impacts there were on Sacramento River temperatures due to systemwide operations of Alternative C, when compared to Existing Condition or the No Project/No Action Alternative.

7F.2.1 Introduction

Two results are included in this appendix, in the following order:

- Detailed results and discussion of the Sites Reservoir temperature model and conclusions specific to the performance of the reservoir and the selective withdrawal outlet structure in meeting river temperature targets.
- Summary results for use in the DEIR/EIS for detailed evaluation for impacts.

7F.2.2 Detailed Results and Discussion

Figures 7F-2 through 7F-9 show the model results over an 82-year period-of-record. The results have been converted to monthly time-series (daily values averaged for each month) and are presented in one figure for every ten years for the period of record. Each plot includes two panels. The top panel shows the time-series of the proposed Sites Reservoir temperatures at elevations 490 feet, 390 feet, and 350 feet outlets. The bottom panel shows storage volume, the proposed Delevan Pipeline releases to the Sacramento River, and Sacramento River flow upstream of Delevan Pipeline discharge location.

In the top panel, if the temperatures at elevations 390 feet were close to elevation 490 feet, then it indicated lack of stratification and less cold water pool volume. If the temperatures at elevation 390 feet were closer to those at elevation 350 feet, and there is significant difference in temperatures at 490 feet and 390 feet, then that condition indicates stratification in the Sites Reservoir and significant amount of cold water pool volume available for withdrawal. The top panel also shows the time-series of the modeled target temperatures, the blended Sacramento River temperatures, and the potential temperature impact due to the blending of releases and flows in the Sacramento River. The potential blending impact to the Sacramento River temperature was plotted on the secondary Y-axis. Positive values of the blend impact indicate that the proposed Sites Reservoir releases temperatures were potentially increasing the river temperatures. Similarly, the negative values in the blend impact time-series indicate that the releases from the proposed Sites Reservoir were potentially cooling the river temperatures. The potential impact shown is the change in Sacramento River temperature from immediately upstream to downstream of the Delevan Pipeline. The impact shown does not include any additional impact that may occur due to changes in systemwide or Sacramento River operations due to the alternative being evaluated. Refer to the Summary Results discussion for more information on how to interpret results for detailed evaluation in the DEIR/EIS.

The bottom panel shows the proposed Sites Reservoir storage volume, the proposed Delevan Pipeline releases to the Sacramento River, and Sacramento River flow upstream of the Delevan Pipeline discharge location.

The bottom panel also shows the storage volume corresponding to the elevation of the three outlets (350 feet, 390 feet, and 490 feet) as indicated by dashed lines parallel to X-axis. During the times when the storage was below an outlet elevation, the temperature reported for that outlet in the top panel was equal to the surface temperature of the reservoir.

Based on Figures 7F-2 through 7F-9, there would be few occurrences where the proposed Sites Reservoir releases were cooling the Sacramento River temperatures. Water years 1924, 1926, 1929, 1945, 1947, 1949, 1954, 1960, 1964, 1971, 1976, 1985, and 1986 show minor cooling impacts in one or more months. In the 82-year period-of-record, there are less than 5 percent of the months with a cooling of 0.2°F or more, as shown in the Table 7F-1, with several of the months falling in the same year. All the occurrences of cooling show less than 1.0°F reduction in Sacramento River temperature, except for April 1964, when the Sacramento River temperatures were less than the target by approximately 1.22°F. For the conditions in April 1964, as shown in Figure 7F-6, the target temperature was approximately 58.4°F and the release temperature was approximately 57.2°F. The reservoir temperature at the top outlet was approximately 60°F and the bottom outlet temperature was 46.6°F. Considering the proposed Sites Reservoir end-of-April storage of approximately 1,530 thousand acre-feet (TAF), the release could have been managed such that the downstream target temperature would have been complied with and any reduction in the river temperatures could have been avoided.

In all the years that show minor cooling impacts, the proposed Sites Reservoir would be at a high storage condition and temperature time-series show that there was significant stratification in the reservoir. If the releases were made from the appropriate outlet, the downstream target temperatures should be managed easily. The model attempts to meet the provided monthly averaged target temperature for the tailwater condition. However, the port optimization logic, used to determine which outlets to release from in the model, includes several limitations. In reality, with the vertical temperature gradients in the Sites Reservoir that existed in the years noted above, it is reasonable to assume that the releases could be managed without causing any cooling impacts to the Sacramento River temperatures. The potential cooling impacts shown would probably be manageable in real-time given adequate monitoring and operator control of the proposed Sites Reservoir selective withdrawal outlet structure.

Based on Figures 7F-2 through 7F-9, there would be more occurrences where the proposed Sites Reservoir releases were warming the Sacramento River temperatures. Water years 1926, 1931, 1932, 1933, 1934, 1936, and 1992 show warming impacts of at least 1.0°F in one or more months. In the 82-year period-of-record, there were 10 percent of the months with a warming of 0.2°F or more, as shown in Table 7F-1, with several of the months falling in the same year. The largest occurrences generally coincide with Dry years, when warm releases from the proposed Sites Reservoir with low storage conditions would be coupled with low flows in the Sacramento River. The warming would be more prevalent in the second or third year in a drought sequence, when the storage volume in the proposed Sites Reservoir would be unable to recover fully from the lack of fills in the winter and spring months.

In the operational scheme assumed for Alternative C, the proposed Sites Reservoir releases large volumes in the early part of extended drought conditions, so that the loss of cold water pool in Shasta Lake and other existing onstream reservoirs would be reduced. This leads to rapid declines in proposed Sites Reservoir storage volumes, warmer temperature conditions in the reservoir, and loss of thermal stratification. Much of the smaller potential warming impacts shown would probably be manageable in real-time given adequate monitoring and operator control of the proposed Sites Reservoir selective withdrawal outlet structure. However, the largest potential warming impacts would likely be unavoidable.

The results from this analysis indicated that, in approximately 98 percent of the months, the proposed Sites Reservoir releases were within a 0.5°F of the receiving Sacramento River water temperatures, as shown in Table 7F-1. Even though the model indicated a small number of months (<5 percent) with a likely cooling impact of 0.2°F or more, the proposed Sites Reservoir temperature results showed that it is possible to avoid such impacts by releasing from appropriate outlets. Only one month showed a cooling of more than °F in the 82 years.

In a few years, mainly in an extended drought period when both Sites Reservoir storage and Sacramento River flow would be low, releases from the proposed Sites Reservoir are likely to cause warming of the receiving Sacramento River water. In less than 1percent of the months, the temperatures in the Sacramento River would increase by 1.0°F or more due to the releases from Sites Reservoir, as shown in Table 7F-2. There are approximately 5 percent of the months with likely warming impact of 0.2°F or more, although most of the months would be within the same year. The most significant warming events would be occurring in the September and October months of drought years.

Table 7F-1
Probability of Exceedance of Change in Sacramento River Temperature Downstream of Delevan Pipeline Due to Blending of Releases from the Proposed Sites Reservoir for Any Month

Probability of Exceedance (Percent)	Change in Sacramento River Temperature (°F)*
1	0.9
5	0.2
10	0.1
20	0.0
30	0.0
40	0.0
50	0.0
60	0.0
70	0.0
80	0.0
90	-0.1
95	-0.2
99	-0.4

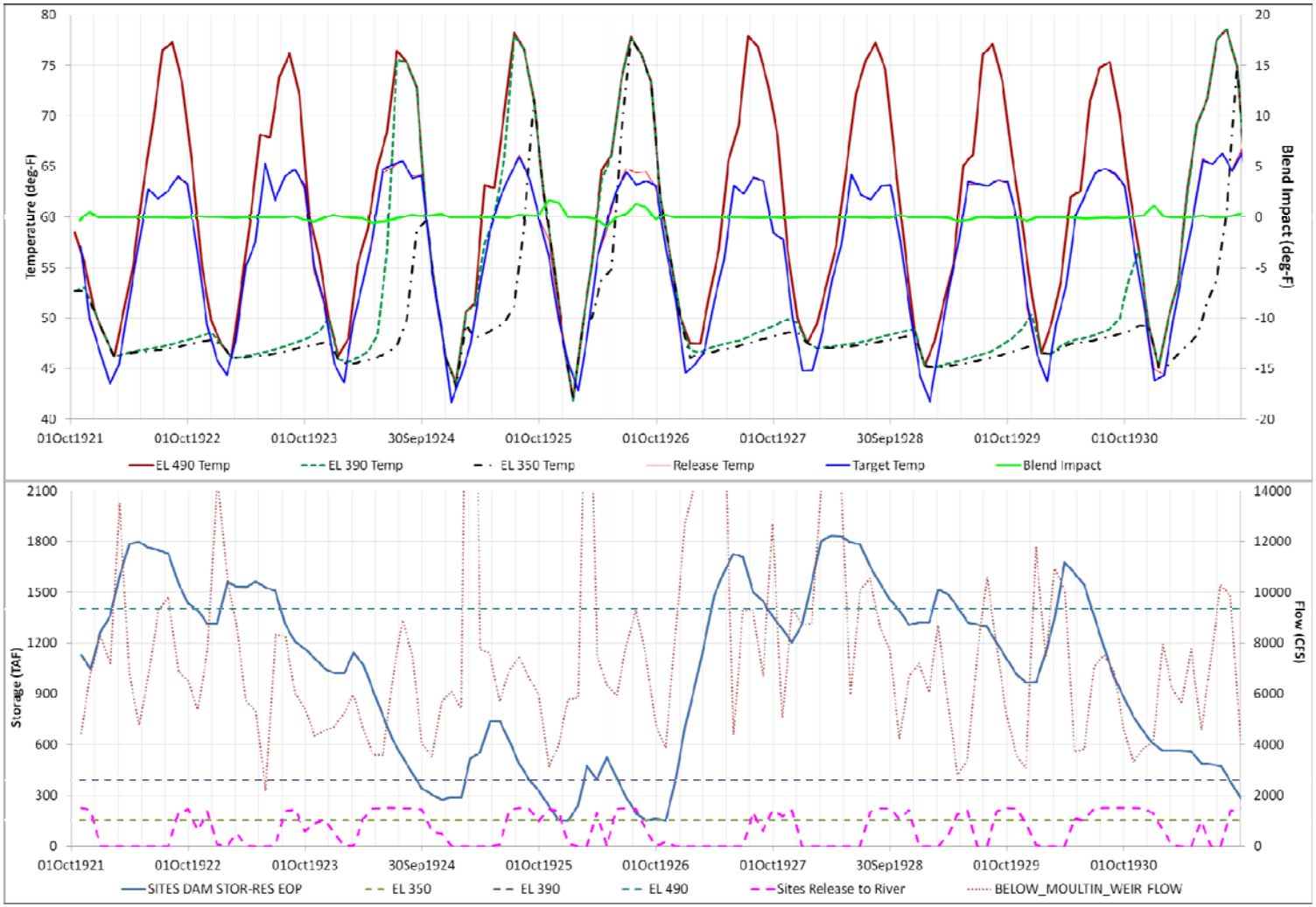
*Negative change indicates cooling of the water temperature and positive change indicates warming.

Table 7F-2
Probability of Exceedance of Change in Sacramento River Temperature Downstream of Delevan Pipeline Due to Blending of Releases from the Proposed Sites Reservoir for a Given Month

Probability of Exceedance (Percent)	Change in Sacramento River Temperature (°F)*											
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	1.2	1.4	0.7	0.0	0.1	0.0	0.0	0.0	0.1	0.6	1.1	0.7
5	0.5	0.6	0.4	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.4	0.4
10	0.3	0.3	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.2
20	0.2	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
30	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
60	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	0.0
70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	0.0
80	-0.1	0.0	0.0	0.0	0.0	0.0	-0.1	0.0	0.0	-0.1	-0.1	-0.1
90	-0.2	-0.1	0.0	0.0	0.0	-0.1	-0.4	-0.2	-0.1	-0.1	-0.2	-0.1
95	-0.3	-0.1	0.0	0.0	-0.1	-0.2	-0.5	-0.3	-0.1	-0.1	-0.3	-0.2
99	-0.5	-0.2	-0.2	0.0	-0.1	-0.3	-1.0	-0.4	-0.2	-0.1	-0.5	-0.4

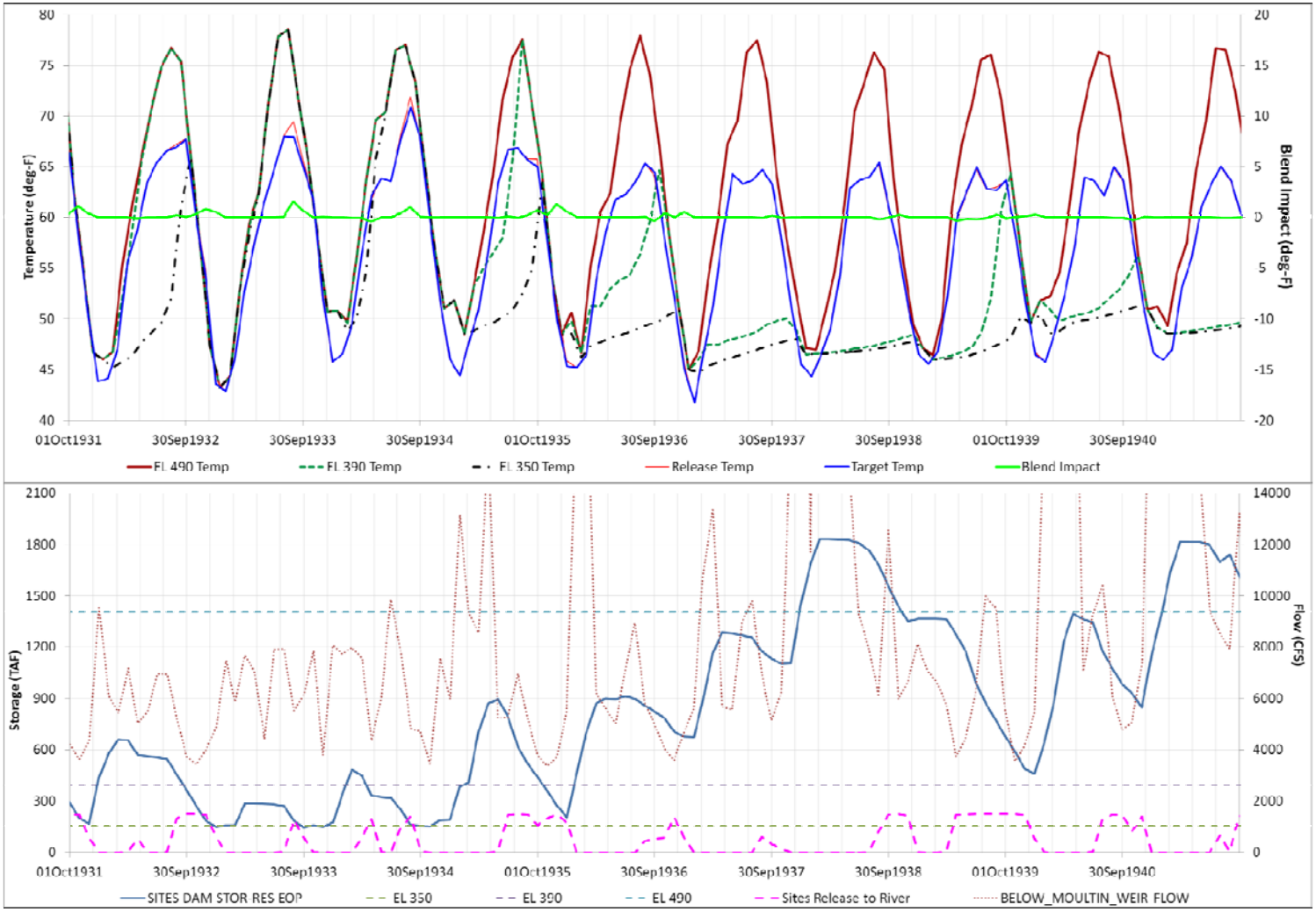
*Negative change indicates cooling of the water temperature and positive change indicates warming.

Figure 7F-2
Temperature Results for Sites Reservoir and the Sacramento River Downstream of the Delevan Pipeline for the Water Years 1922-1931



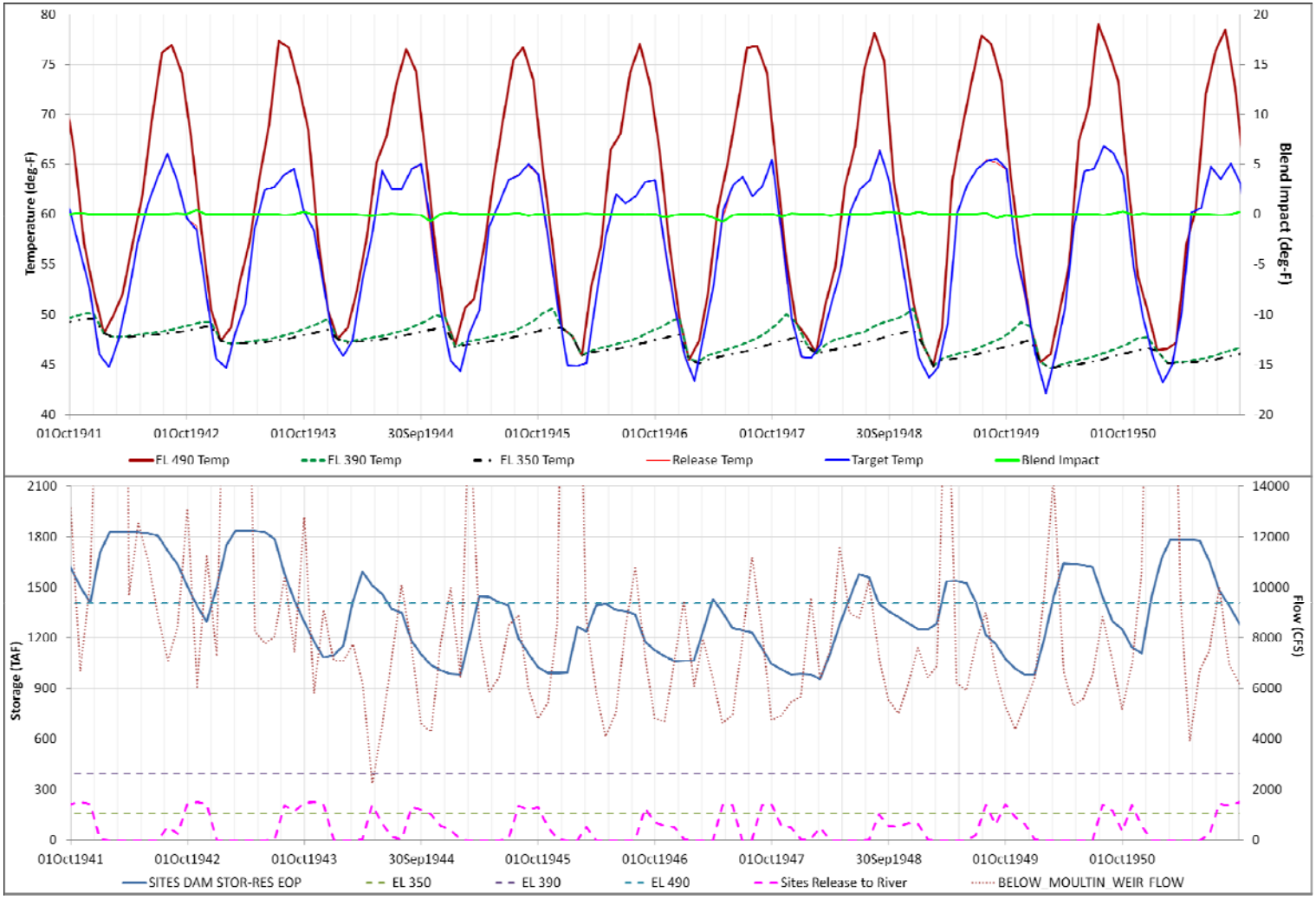
Note: When the storage is below an outlet elevation (indicated by dashed lines parallel to the X-axis in the bottom panel), the temperature reported for that outlet is equal to the surface temperature of the reservoir.

Figure 7F-3
Temperature Results for Sites Reservoir and the Sacramento River Downstream of the Delevan Pipeline for the Water Years 1932-1941



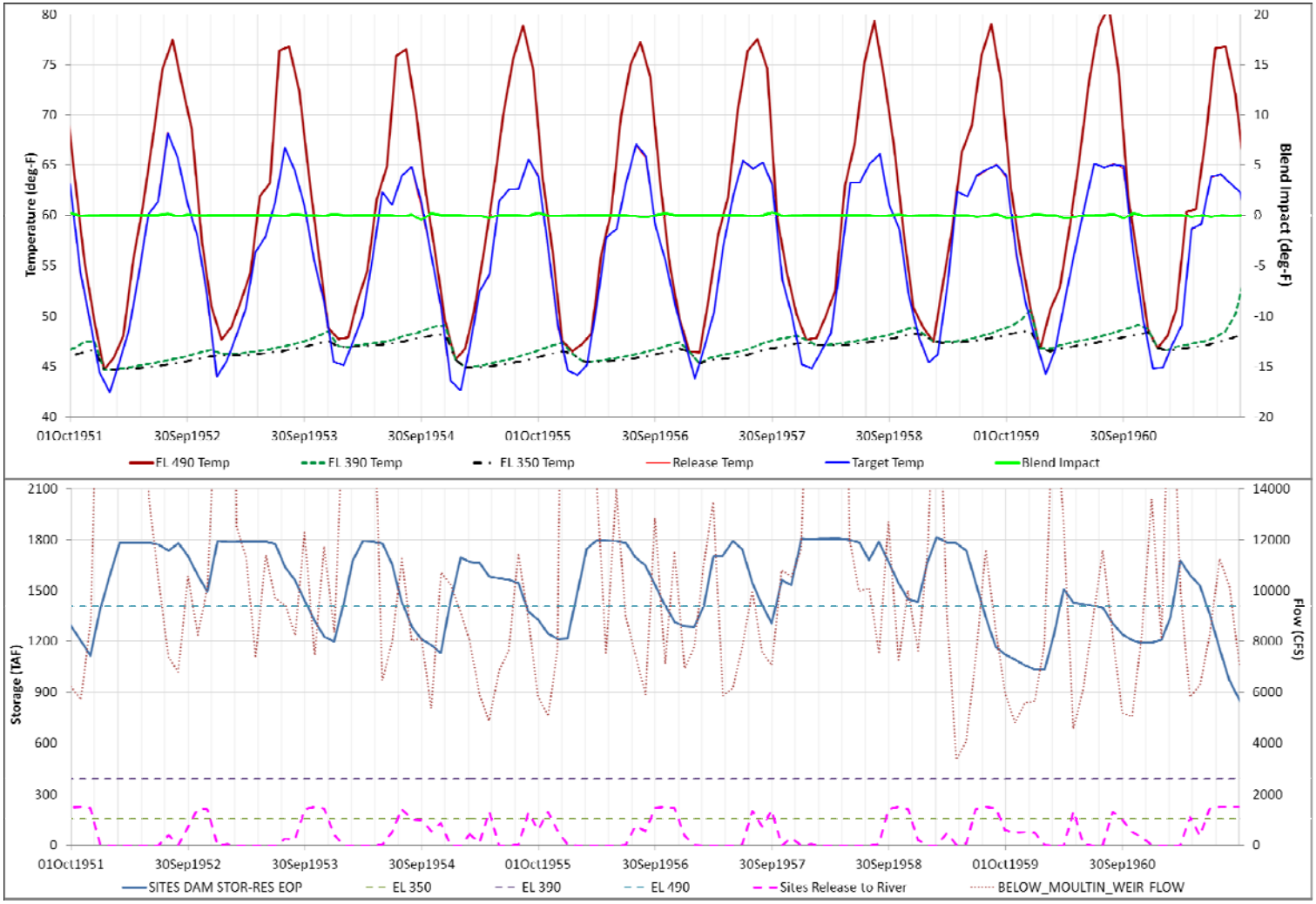
Note: When the storage is below an outlet elevation (indicated by dashed lines parallel to the X-axis in the bottom panel), the temperature reported for that outlet is equal to the surface temperature of the reservoir.

Figure 7F-4
Temperature Results for Sites Reservoir and the Sacramento River Downstream of the Delevan Pipeline for the Water Years 1942-1951



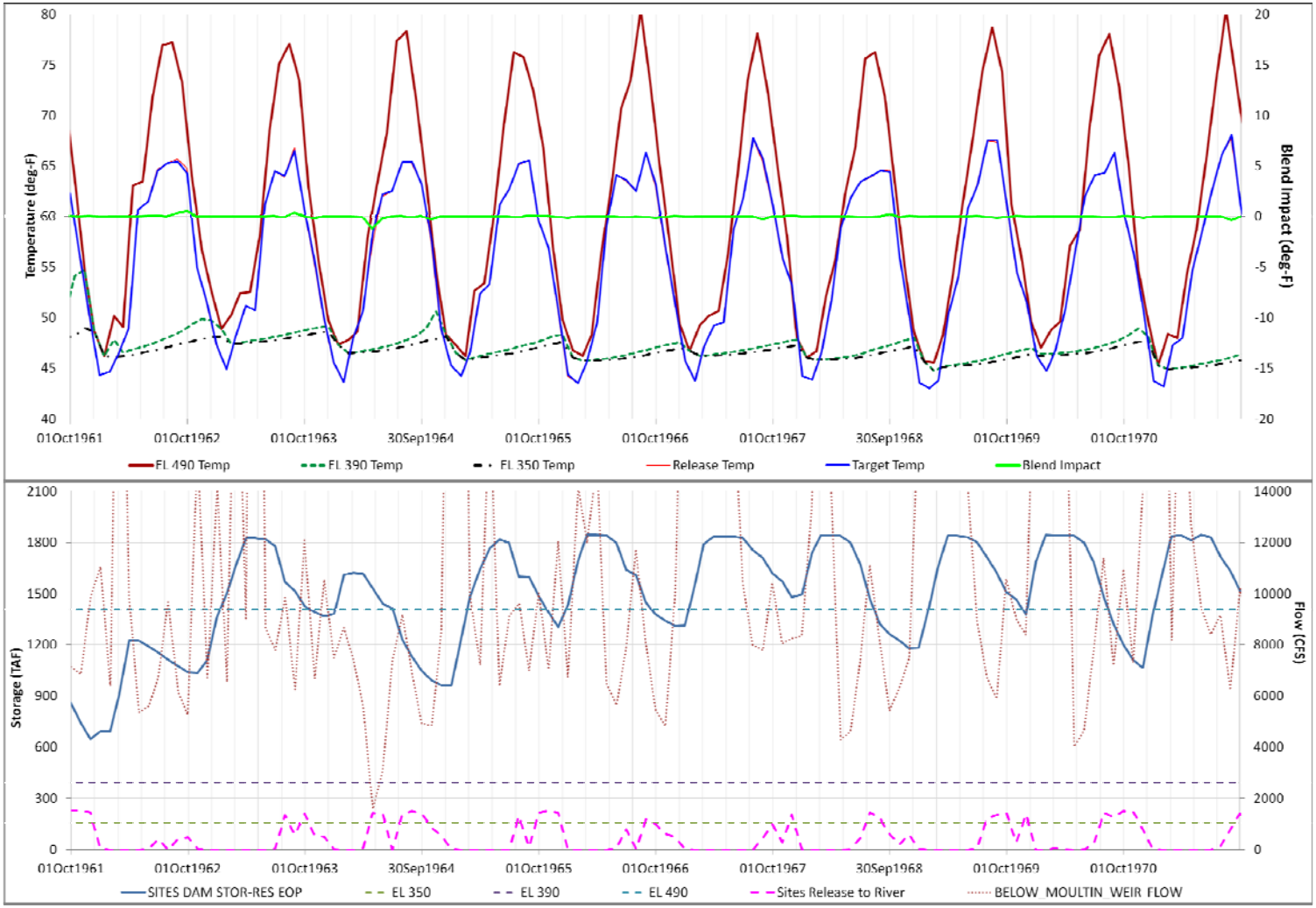
Note: When the storage is below an outlet elevation (indicated by dashed lines parallel to the X-axis in the bottom panel), the temperature reported for that outlet is equal to the surface temperature of the reservoir.

Figure 7F-5
Temperature Results for Sites Reservoir and the Sacramento River Downstream of the Delevan Pipeline for the Water Years 1952-1961



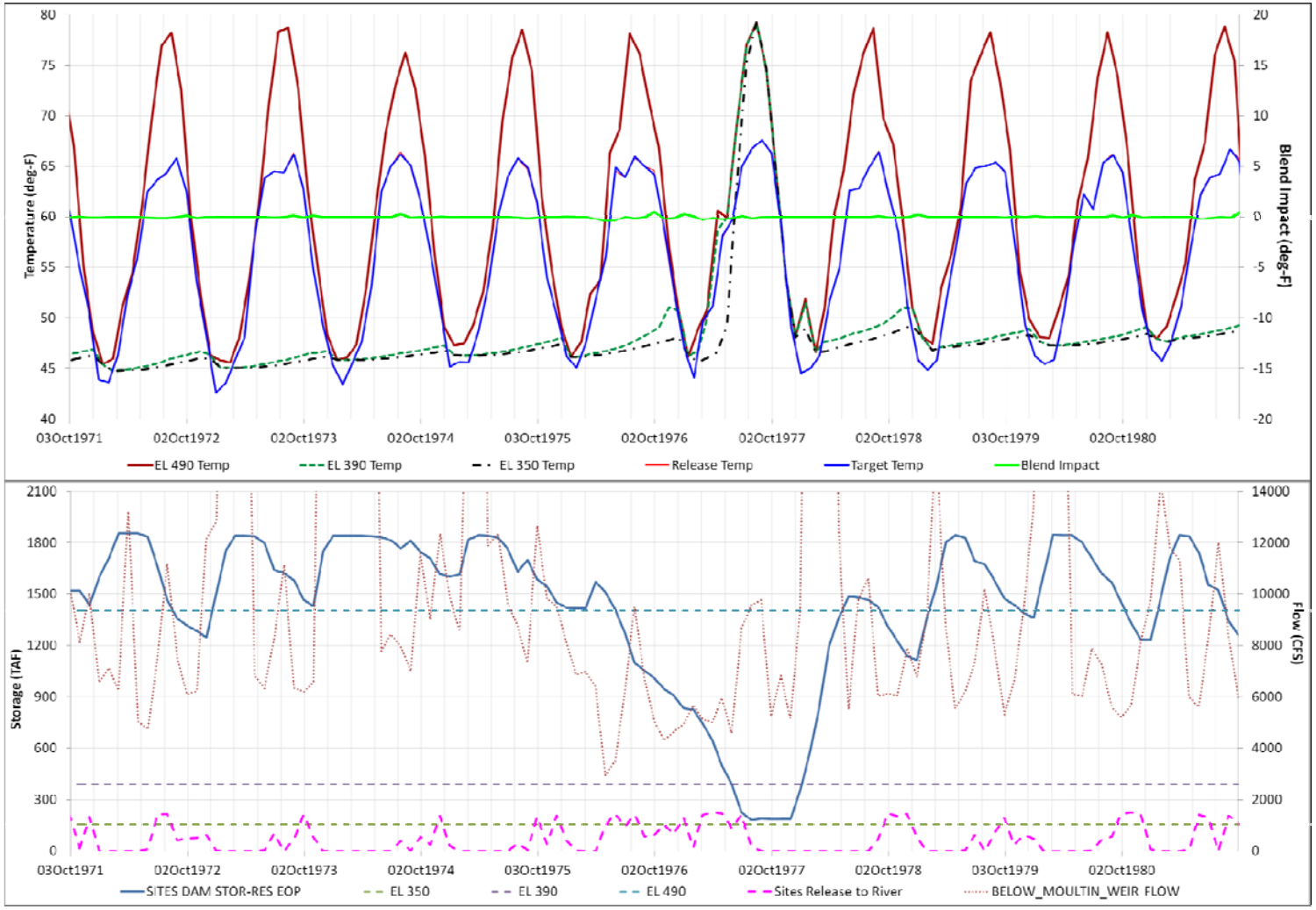
Note: When the storage is below an outlet elevation (indicated by dashed lines parallel to the X-axis in the bottom panel), the temperature reported for that outlet is equal to the surface temperature of the reservoir.

Figure 7F-6
Temperature Results for Sites Reservoir and the Sacramento River Downstream of the Delevan Pipeline for the Water Years 1962-1971



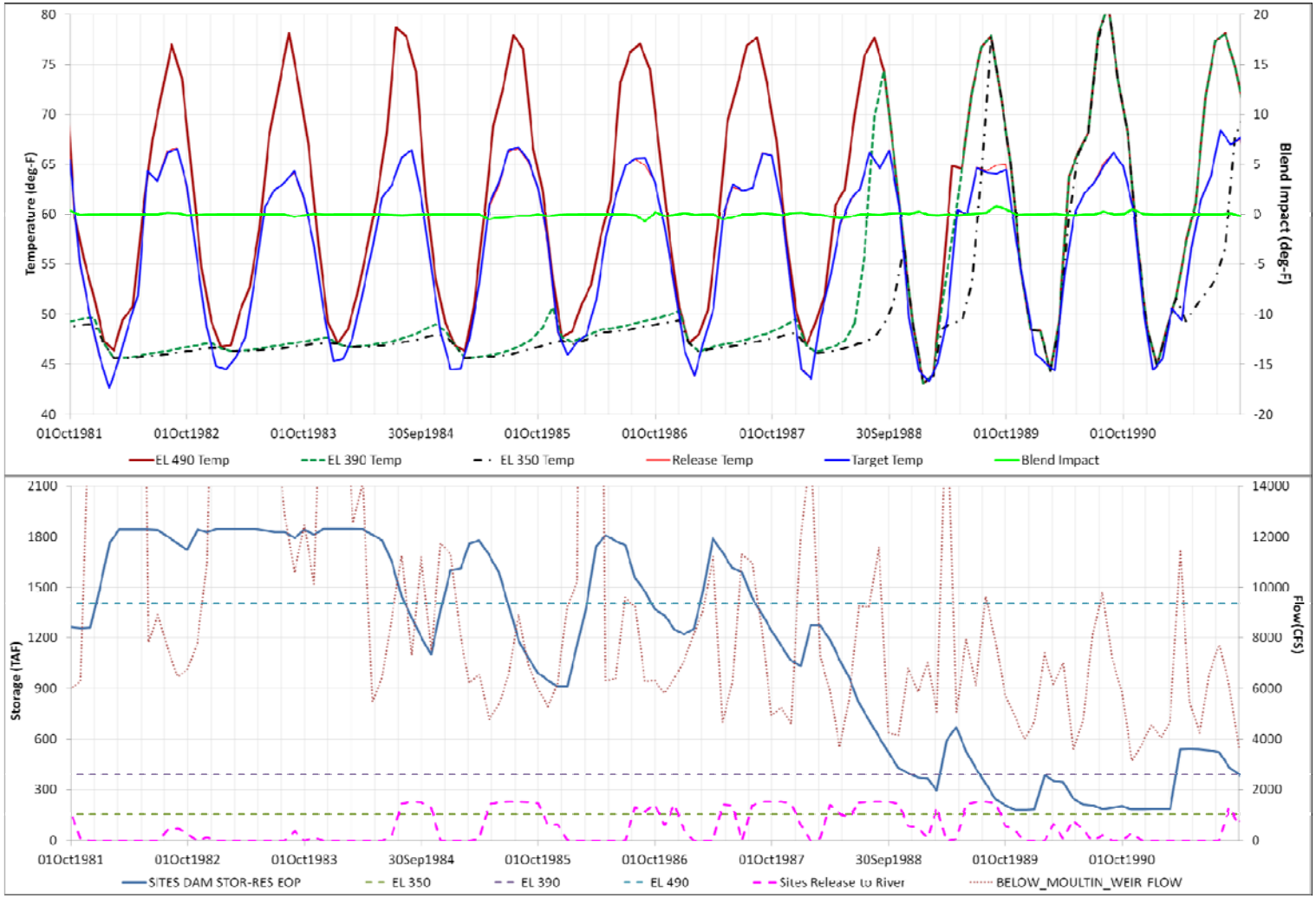
Note: When the storage is below an outlet elevation (indicated by dashed lines parallel to the X-axis in the bottom panel), the temperature reported for that outlet is equal to the surface temperature of the reservoir.

Figure 7F-7
Temperature Results for Sites Reservoir and the Sacramento River Downstream of the Delevan Pipeline for the Water Years 1972-1981



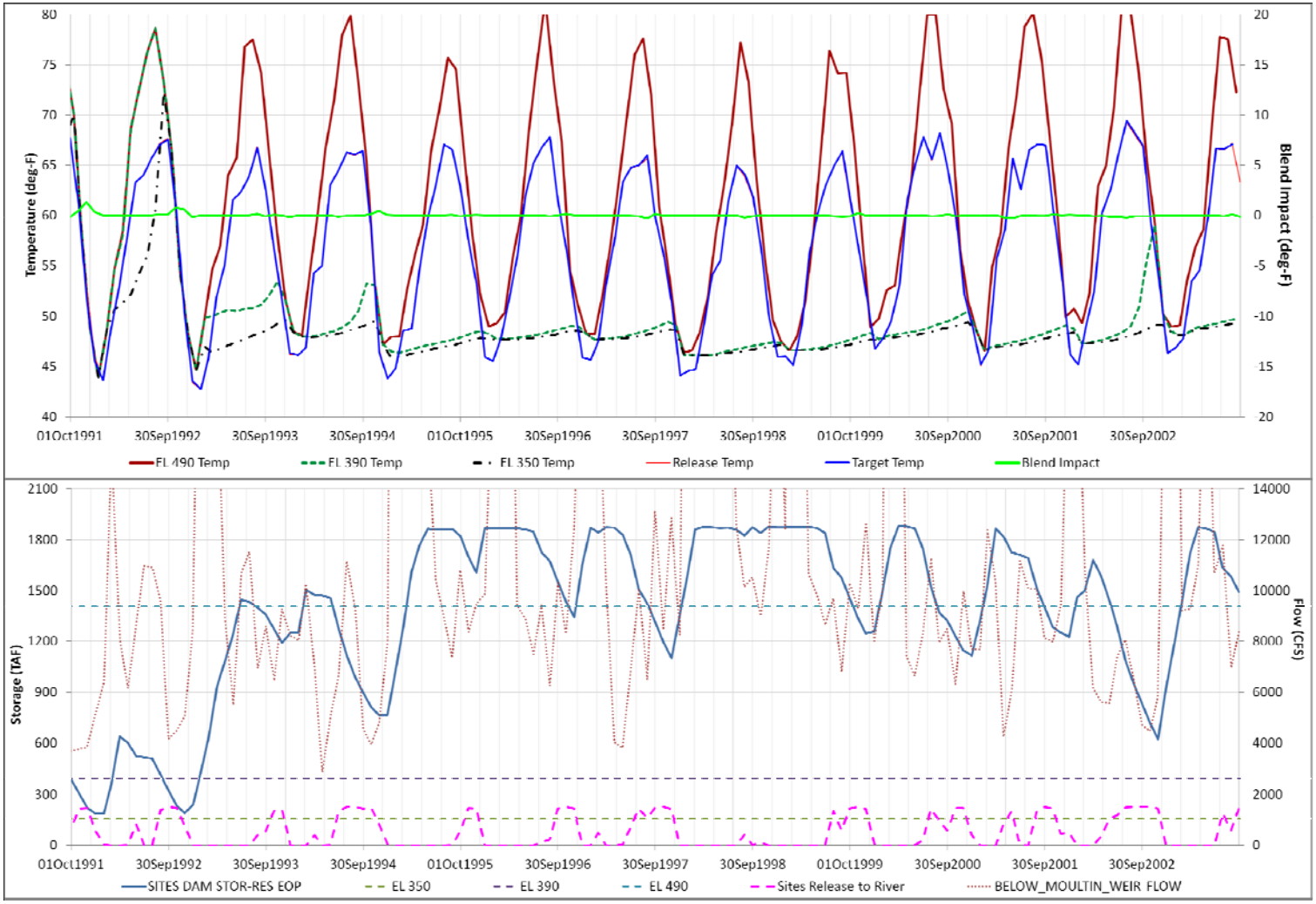
Note: When the storage is below an outlet elevation (indicated by dashed lines parallel to the X-axis in the bottom panel), the temperature reported for that outlet is equal to the surface temperature of the reservoir.

Figure 7F-8
Temperature Results for Sites Reservoir and the Sacramento River Downstream of the Delevan Pipeline for the Water Years 1982-1991



Note: When the storage is below an outlet elevation (indicated by dashed lines parallel to the X-axis in the bottom panel), the temperature reported for that outlet is equal to the surface temperature of the reservoir.

Figure 7F-9
Temperature Results for Sites Reservoir and the Sacramento River Downstream of the Delevan Pipeline for the Water Years 1992-2003



Note: When the storage is below an outlet elevation (indicated by dashed lines parallel to the X-axis in the bottom panel), the temperature reported for that outlet is equal to the surface temperature of the reservoir.

7F.2.3 Summary Results

The proposed Sites Reservoir discharge temperature modeling results are used in Chapter 7 Surface Water Quality in conjunction with Sacramento River temperature model results discussed in Appendix 7E.

For each parameter and location shown in Table 7F-3, Summary Tables reports are provided. In the Summary Tables reports, for each parameter and location shown below, summary tables of temperature modeling results by month were included. The tables include long-term average, and averages by water year type (SWRCB 40-30-30 Index). The tables also include the absolute and relative differences between alternatives.

Other analyses were used to estimate river temperature conditions. The temperature modeling using the USRWQM and RECTEMP models, referred to in Chapter 7 for evaluating temperature conditions for locations in the Trinity River, Sacramento River, Feather River, and American River is included in Appendix 7E.

Table 7F-3
Sites Reservoir Discharge Temperature Modeling Results Locations and Parameters

	Report Title	Time-Step	Parameter
1	Sacramento River at Tehama-Colusa Canal Intake	Monthly	Temperature
2	Sacramento River at Glenn-Colusa Irrigation District Canal Intake	Monthly	Temperature
3	Sacramento River at Delevan Pipeline Intake	Monthly	Temperature
4	Sacramento River downstream of Delevan Pipeline	Monthly	Temperature
5	Funks Reservoir	Monthly	Temperature

7F.2.4 Comparisons

Summary Tables reports are provided for one comparison:

- Alternative C compared to the No Project/No Action Alternative

The impact shown by the comparison above does not include any impact that may occur due to changes in systemwide or Sacramento River operations due to the alternative being evaluated. To derive the total impact of changes in the river operations and changes in the discharge blending, the impact shown must be added to the results of Sacramento River temperature results presented in Appendix 7E.

Sacramento River at Tehama Colusa Canal Intake, Monthly Average Temperature

Long-term Average and Average by Water Year Type

Analysis Period	Monthly Average Temperature (deg-F)											
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Long-term												
Full Simulation Period[1]												
No Action Alternative	55.4	51.0	46.1	44.5	46.2	49.7	53.4	56.5	57.1	57.9	58.8	59.0
NODOS Alternative C	55.1	50.8	46.3	44.7	46.3	49.7	53.9	56.6	57.1	57.9	58.5	58.6
Difference	-0.4	-0.2	0.2	0.2	0.0	0.0	0.5	0.1	0.0	0.0	-0.3	-0.3
Percent Difference[3]	-0.7%	-0.3%	0.5%	0.5%	0.1%	0.1%	0.9%	0.2%	0.1%	-0.1%	-0.5%	-0.6%
Water Year Types[2]												
Wet (32%)												
No Action Alternative	55.0	51.5	46.5	44.4	45.8	48.9	52.7	56.5	56.9	58.0	58.1	57.2
NODOS Alternative C	54.9	51.5	46.8	44.5	45.8	48.9	52.8	56.3	56.7	58.0	58.2	57.1
Difference	-0.1	0.0	0.3	0.1	0.0	0.0	0.1	-0.3	-0.2	0.0	0.1	-0.1
Percent Difference	-0.2%	-0.1%	0.6%	0.3%	0.0%	0.0%	0.1%	-0.5%	-0.3%	0.0%	0.2%	-0.2%
Above Normal (15%)												
No Action Alternative	54.9	50.7	46.3	44.9	46.2	49.8	53.7	57.1	57.0	57.3	58.3	58.3
NODOS Alternative C	54.6	50.6	46.6	45.0	46.3	49.9	54.1	57.1	57.1	57.5	58.3	58.2
Difference	-0.3	-0.1	0.3	0.2	0.0	0.0	0.4	0.0	0.1	0.1	0.0	-0.1
Percent Difference	-0.6%	-0.2%	0.6%	0.4%	0.1%	0.1%	0.8%	0.0%	0.1%	0.2%	-0.1%	-0.2%
Below Normal (17%)												
No Action Alternative	54.2	50.7	46.0	44.5	46.1	49.3	53.6	56.1	56.7	57.3	58.2	58.0
NODOS Alternative C	53.7	50.5	46.4	44.8	46.2	49.3	54.0	56.2	56.7	57.3	58.4	57.8
Difference	-0.5	-0.3	0.4	0.3	0.0	0.1	0.4	0.1	0.0	0.1	0.2	-0.2
Percent Difference	-0.9%	-0.5%	0.9%	0.6%	0.0%	0.1%	0.7%	0.1%	0.0%	0.1%	0.3%	-0.3%
Dry (22%)												
No Action Alternative	55.6	50.7	46.1	44.4	46.3	50.6	53.6	56.1	57.0	57.7	59.1	60.3
NODOS Alternative C	55.2	50.5	46.0	44.7	46.3	50.7	54.5	56.5	57.4	57.8	58.6	59.5
Difference	-0.4	-0.2	-0.1	0.3	0.0	0.1	0.9	0.5	0.4	0.1	-0.4	-0.8
Percent Difference	-0.7%	-0.4%	-0.2%	0.6%	0.0%	0.2%	1.6%	0.8%	0.7%	0.1%	-0.7%	-1.3%
Critical (15%)												
No Action Alternative	57.5	50.7	45.1	44.3	46.9	50.4	53.8	56.3	57.7	59.3	60.8	61.9
NODOS Alternative C	56.8	50.4	45.3	44.6	47.0	50.4	54.7	56.8	57.9	58.8	59.3	61.2
Difference	-0.7	-0.3	0.2	0.3	0.1	0.1	0.9	0.5	0.1	-0.5	-1.5	-0.7
Percent Difference	-1.3%	-0.6%	0.4%	0.6%	0.1%	0.1%	1.6%	0.9%	0.2%	-0.8%	-2.4%	-1.2%

1 Based on the 82-year simulation period

2 As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999)

3 Relative difference of the monthly average

Sacramento River at Glenn Colusa Canal Intake, Monthly Average Temperature

Long-term Average and Average by Water Year Type

Analysis Period	Monthly Average Temperature (deg-F)											
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Long-term												
Full Simulation Period[1]												
No Action Alternative	55.9	50.8	45.6	44.4	46.6	50.5	54.7	58.5	59.2	60.1	60.8	60.3
NODOS Alternative C	55.7	50.7	45.8	44.6	46.6	50.5	55.1	58.6	59.2	60.0	60.6	60.0
Difference	-0.3	-0.2	0.2	0.2	0.0	0.0	0.5	0.2	0.1	0.0	-0.2	-0.3
Percent Difference[3]	-0.5%	-0.3%	0.0%	0.3%	0.0%	0.1%	0.9%	0.3%	0.1%	-0.1%	-0.4%	-0.4%
Water Year Types[2]												
Wet (32%)												
No Action Alternative	55.5	51.4	46.0	44.4	46.1	49.6	53.8	58.6	59.2	60.3	60.1	58.5
NODOS Alternative C	55.4	51.3	46.3	44.5	46.1	49.6	53.9	58.4	59.0	60.3	60.3	58.5
Difference	-0.1	0.0	0.2	0.1	0.0	0.0	0.1	-0.2	-0.2	0.0	0.2	-0.1
Percent Difference	-0.2%	-0.1%	0.5%	0.2%	0.0%	0.0%	0.1%	-0.3%	-0.4%	0.0%	0.3%	-0.1%
Above Normal (15%)												
No Action Alternative	55.5	50.6	45.8	44.9	46.6	50.6	55.0	59.2	59.3	59.4	60.4	59.8
NODOS Alternative C	55.2	50.5	46.0	44.9	46.6	50.7	55.4	59.2	59.3	59.5	60.4	59.7
Difference	-0.3	-0.1	0.2	0.1	0.0	0.1	0.4	0.0	0.0	0.1	0.0	-0.1
Percent Difference	-0.5%	-0.2%	0.4%	0.2%	0.0%	0.1%	0.8%	0.1%	0.1%	0.2%	0.0%	-0.1%
Below Normal (17%)												
No Action Alternative	54.8	50.7	45.5	44.4	46.5	50.0	54.9	58.2	58.8	59.4	60.2	59.4
NODOS Alternative C	54.4	50.5	45.8	44.7	46.5	50.0	55.3	58.3	58.8	59.5	60.4	59.3
Difference	-0.4	-0.2	0.3	0.2	0.0	0.1	0.4	0.1	0.0	0.1	0.2	-0.1
Percent Difference	-0.7%	-0.5%	0.7%	0.5%	0.0%	0.1%	0.7%	0.2%	0.0%	0.1%	0.4%	-0.2%
Dry (22%)												
No Action Alternative	56.1	50.6	45.8	44.2	46.6	51.4	55.0	58.0	59.0	59.8	61.0	61.8
NODOS Alternative C	55.8	50.5	45.7	44.4	46.6	51.5	55.9	58.5	59.4	59.9	60.6	61.1
Difference	-0.3	-0.2	-0.1	0.2	0.0	0.1	0.9	0.5	0.5	0.1	-0.3	-0.7
Percent Difference	-0.5%	-0.3%	-0.2%	0.5%	0.0%	0.2%	1.6%	0.9%	0.8%	0.2%	-0.6%	-1.1%
Critical (15%)												
No Action Alternative	57.8	50.6	44.8	44.2	47.3	51.2	55.2	58.1	59.5	61.1	62.6	63.0
NODOS Alternative C	57.2	50.3	44.9	44.4	47.4	51.3	56.1	58.7	59.7	60.7	61.2	62.5
Difference	-0.5	-0.3	0.1	0.2	0.0	0.1	0.9	0.6	0.2	-0.4	-1.4	-0.5
Percent Difference	-0.9%	-0.6%	0.3%	0.5%	0.1%	0.1%	1.6%	1.0%	0.3%	-0.7%	-2.2%	-0.9%

1 Based on the 82-year simulation period

2 As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999)

3 Relative difference of the monthly average

Sacramento River at Delevan Pipeline Intake, Monthly Average Temperature

Long-term Average and Average by Water Year Type

Analysis Period	Monthly Average Temperature (deg-F)											
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Long-term												
Full Simulation Period[1]												
No Action Alternative	57.3	51.0	45.3	44.4	47.0	51.4	56.7	61.9	64.0	65.5	65.7	63.4
NODOS Alternative C	57.1	50.8	45.4	44.5	47.0	51.5	57.1	62.1	63.6	65.0	65.5	63.2
Difference	-0.1	-0.1	0.1	0.1	0.0	0.1	0.4	0.2	-0.3	-0.5	-0.2	-0.2
Percent Difference[3]	-0.2%	-0.2%	0.1%	0.1%	0.0%	0.2%	0.8%	0.3%	-0.5%	-0.7%	-0.4%	-0.2%
Water Year Types[2]												
Wet (32%)												
No Action Alternative	56.9	51.3	45.7	44.3	46.3	50.3	55.0	61.4	63.7	65.9	65.3	61.6
NODOS Alternative C	56.8	51.3	45.8	44.4	46.3	50.4	55.2	61.4	63.0	65.4	65.5	61.5
Difference	-0.1	0.0	0.1	0.0	0.0	0.0	0.1	-0.1	-0.6	-0.5	0.2	-0.1
Percent Difference	-0.2%	-0.1%	0.2%	0.0%	0.0%	0.1%	0.2%	-0.1%	-1.0%	-0.7%	0.3%	-0.1%
Above Normal (15%)												
No Action Alternative	57.0	50.8	45.4	45.0	47.0	51.6	56.9	62.6	64.4	64.8	65.6	63.0
NODOS Alternative C	56.9	50.7	45.5	45.0	47.0	51.8	57.4	62.6	63.9	64.4	65.6	63.0
Difference	-0.2	-0.1	0.1	0.0	0.0	0.1	0.4	0.1	-0.5	-0.5	0.0	0.0
Percent Difference	-0.3%	-0.2%	0.2%	0.0%	0.0%	0.3%	0.8%	0.1%	-0.8%	-0.7%	0.1%	0.1%
Below Normal (17%)												
No Action Alternative	56.2	50.9	45.1	44.4	46.9	50.8	56.8	61.7	63.8	65.2	65.4	62.8
NODOS Alternative C	56.0	50.8	45.3	44.6	46.9	50.9	57.3	61.8	63.5	64.7	65.4	62.8
Difference	-0.2	-0.2	0.2	0.1	0.0	0.1	0.4	0.2	-0.4	-0.5	0.1	0.0
Percent Difference	-0.3%	-0.3%	0.4%	0.3%	0.0%	0.2%	0.8%	0.3%	-0.5%	-0.8%	0.1%	0.0%
Dry (22%)												
No Action Alternative	57.5	50.8	45.6	44.1	47.2	52.7	57.8	62.0	64.0	65.2	65.8	64.9
NODOS Alternative C	57.4	50.6	45.4	44.2	47.2	52.8	58.8	62.5	64.1	64.9	65.4	64.4
Difference	-0.1	-0.2	-0.1	0.1	0.0	0.1	0.9	0.5	0.1	-0.3	-0.4	-0.5
Percent Difference	-0.2%	-0.4%	-0.3%	0.2%	-0.1%	0.3%	1.6%	0.9%	0.1%	-0.5%	-0.5%	-0.8%
Critical (15%)												
No Action Alternative	58.7	50.7	44.6	44.2	48.0	52.4	58.0	61.9	64.1	66.0	66.9	65.6
NODOS Alternative C	58.6	50.5	44.7	44.3	48.0	52.5	58.5	62.4	64.0	65.4	65.5	65.3
Difference	-0.2	-0.2	0.0	0.1	0.0	0.1	0.5	0.5	-0.1	-0.5	-1.3	-0.3
Percent Difference	-0.3%	-0.4%	0.1%	0.3%	0.0%	0.1%	0.8%	0.8%	-0.2%	-0.8%	-2.0%	-0.4%

1 Based on the 82-year simulation period

2 As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999)

3 Relative difference of the monthly average

Sacramento River below Delevan Pipeline, Monthly Average Temperature

Long-term Average and Average by Water Year Type

Analysis Period	Monthly Average Temperature (deg-F)											
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Long-term												
Full Simulation Period[1]												
No Action Alternative	57.3	51.0	45.3	44.4	47.0	51.4	56.7	61.9	64.0	65.5	65.7	63.4
NODOS Alternative C	57.2	50.9	45.5	44.5	47.0	51.5	57.1	62.0	63.6	64.9	65.4	63.2
Difference	-0.1	0.0	0.1	0.1	0.0	0.1	0.3	0.1	-0.4	-0.5	-0.3	-0.2
Percent Difference[3]	-0.2%	-0.1%	0.3%	0.1%	0.0%	0.2%	0.6%	0.2%	-0.6%	-0.8%	-0.5%	-0.3%
Water Year Types[2]												
Wet (32%)												
No Action Alternative	56.9	51.3	45.7	44.3	46.3	50.3	55.0	61.4	63.7	65.9	65.3	61.6
NODOS Alternative C	56.9	51.3	45.8	44.4	46.3	50.4	55.2	61.4	63.0	65.3	65.3	61.5
Difference	-0.1	0.0	0.1	0.0	0.0	0.0	0.1	-0.1	-0.6	-0.6	0.0	-0.1
Percent Difference	-0.1%	-0.1%	0.3%	0.0%	0.0%	0.1%	0.2%	-0.1%	-1.0%	-0.9%	0.0%	-0.2%
Above Normal (15%)												
No Action Alternative	57.0	50.8	45.4	45.0	47.0	51.6	56.9	62.6	64.4	64.8	65.6	63.0
NODOS Alternative C	56.8	50.8	45.6	45.0	47.0	51.8	57.4	62.6	63.9	64.2	65.4	63.0
Difference	-0.2	0.0	0.2	0.0	0.0	0.1	0.4	0.1	-0.5	-0.6	-0.2	0.0
Percent Difference	-0.4%	0.1%	0.4%	0.0%	0.0%	0.3%	0.7%	0.1%	-0.8%	-0.9%	-0.3%	0.0%
Below Normal (17%)												
No Action Alternative	56.2	50.9	45.1	44.4	46.9	50.8	56.8	61.7	63.8	65.2	65.4	62.8
NODOS Alternative C	56.1	50.9	45.3	44.6	46.9	50.9	57.3	61.8	63.4	64.6	65.3	62.8
Difference	-0.1	-0.1	0.2	0.1	0.0	0.1	0.4	0.2	-0.4	-0.6	-0.1	0.0
Percent Difference	-0.2%	-0.1%	0.5%	0.3%	-0.1%	0.2%	0.7%	0.2%	-0.7%	-0.9%	-0.1%	-0.1%
Dry (22%)												
No Action Alternative	57.5	50.8	45.6	44.1	47.2	52.7	57.8	62.0	64.0	65.2	65.8	64.9
NODOS Alternative C	57.3	50.6	45.4	44.2	47.2	52.8	58.5	62.3	63.9	64.9	65.5	64.4
Difference	-0.2	-0.2	-0.1	0.1	0.0	0.1	0.6	0.3	0.0	-0.3	-0.3	-0.5
Percent Difference	-0.4%	-0.4%	-0.3%	0.2%	-0.1%	0.2%	1.1%	0.5%	0.0%	-0.5%	-0.5%	-0.8%
Critical (15%)												
No Action Alternative	58.7	50.7	44.6	44.2	48.0	52.4	58.0	61.9	64.1	66.0	66.9	65.6
NODOS Alternative C	58.8	50.7	44.8	44.3	48.0	52.4	58.3	62.3	64.0	65.4	65.6	65.4
Difference	0.0	0.0	0.2	0.2	0.0	0.0	0.3	0.3	-0.2	-0.5	-1.3	-0.3
Percent Difference	0.0%	0.0%	0.4%	0.3%	-0.1%	0.0%	0.4%	0.5%	-0.3%	-0.8%	-1.9%	-0.4%

1 Based on the 82-year simulation period

2 As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999)

3 Relative difference of the monthly average

Funks Reservoir, Monthly Average Temperature

Long-term Average and Average by Water Year Type

	Monthly Average Temperature (deg-F)											
Analysis Period	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Long-term												
Full Simulation Period[1]												
No Action Alternative	55.4	51.0	46.1	44.5	46.2	49.7	53.4	56.5	57.1	57.9	58.8	59.0
NODOS Alternative C	57.2	51.3	46.7	45.0	46.4	50.1	55.0	59.2	61.9	63.6	63.9	62.9
Difference	1.8	0.4	0.7	0.5	0.1	0.4	1.6	2.7	4.9	5.7	5.1	4.0
Percent Difference[3]	3.2%	0.7%	1.5%	1.1%	0.3%	0.7%	2.9%	4.8%	8.5%	9.8%	8.7%	6.8%
Water Year Types[2]												
Wet (32%)												
No Action Alternative	55.0	51.5	46.5	44.4	45.8	48.9	52.7	56.5	56.9	58.0	58.1	57.2
NODOS Alternative C	56.8	51.4	46.9	44.8	45.9	49.0	52.9	57.2	60.7	62.9	61.2	60.7
Difference	1.9	-0.2	0.4	0.4	0.1	0.0	0.2	0.7	3.8	5.0	3.1	3.6
Percent Difference	3.4%	-0.3%	0.8%	0.9%	0.2%	0.1%	0.4%	1.2%	6.7%	8.6%	5.4%	6.2%
Above Normal (15%)												
No Action Alternative	54.9	50.7	46.3	44.9	46.2	49.8	53.7	57.1	57.0	57.3	58.3	58.3
NODOS Alternative C	56.7	51.1	47.1	45.1	46.6	50.1	54.7	59.0	62.1	62.9	63.8	62.4
Difference	1.8	0.4	0.8	0.2	0.4	0.3	1.0	1.9	5.0	5.5	5.5	4.1
Percent Difference	3.2%	0.9%	1.7%	0.5%	0.8%	0.5%	1.9%	3.3%	8.8%	9.7%	9.4%	7.0%
Below Normal (17%)												
No Action Alternative	54.2	50.7	46.0	44.5	46.1	49.3	53.6	56.1	56.7	57.3	58.2	58.0
NODOS Alternative C	55.9	51.1	46.7	44.9	46.4	49.5	54.7	58.4	61.2	63.1	63.8	62.7
Difference	1.7	0.4	0.8	0.4	0.2	0.2	1.1	2.3	4.5	5.8	5.6	4.7
Percent Difference	3.1%	0.7%	1.6%	0.9%	0.5%	0.4%	2.1%	4.1%	7.9%	10.2%	9.7%	8.1%
Dry (22%)												
No Action Alternative	55.6	50.7	46.1	44.4	46.3	50.6	53.6	56.1	57.0	57.7	59.1	60.3
NODOS Alternative C	57.0	51.1	46.7	44.9	46.3	51.2	56.4	60.9	62.9	64.4	65.9	64.5
Difference	1.4	0.4	0.6	0.5	0.0	0.6	2.8	4.9	5.9	6.7	6.9	4.2
Percent Difference	2.6%	0.8%	1.3%	1.1%	-0.1%	1.1%	5.2%	8.7%	10.4%	11.6%	11.6%	6.9%
Critical (15%)												
No Action Alternative	57.5	50.7	45.1	44.3	46.9	50.4	53.8	56.3	57.7	59.3	60.8	61.9
NODOS Alternative C	59.4	51.8	46.2	45.2	46.9	51.3	57.4	61.6	63.5	65.4	66.5	65.8
Difference	1.9	1.1	1.1	0.9	0.0	0.9	3.5	5.3	5.7	6.1	5.8	3.8
Percent Difference	3.2%	2.2%	2.4%	2.0%	0.0%	1.9%	6.6%	9.4%	9.9%	10.2%	9.5%	6.1%

1 Based on the 82-year simulation period

2 As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999)

3 Relative difference of the monthly average